Polymer Coating by ATRP in MR Fluids

Magnetorheological (MR) fluids are suspensions of magnetizable particles (e.g., iron particles) in a viscous or viscoelastic carrier fluid. MR fluids are field-controllable materials, whose rheological properties can be dramatically altered by applying a magnetic field. A MR fluid is in a free-flowing liquid state in the absence of a magnetic field. However, apparent viscosity can be increased by one or two orders of magnitude under a strong magnetic field in a very short time (milliseconds) and it exhibits solid-like characteristics. A novel magnetorheological fluid, in which the surface of iron particles are coated with poly (butyl acrylate) by surface initiated atom transfer radical polymerization (ATRP), is investigated. The polymer coating procedure includes two steps, which are immobilization of initiator: 2-4(-chlorosulfonylphenyl)-ethytrichlorosilane (CTCS) on the iron particles surface and graft polymerization of butyl acrylate from the surface. The surface coating is characterized by FTIR and SEM. The rheological properties of MR fluid synthesized by ATRP was investigated using a magnetic rheometer. Experiments confirmed that the rheological behavior can be described by the Bingham equation. This magnetorheological fluid has controllable off-state viscosity and high shear yield stress. One of the most significant challenges for MR fluid in many applications is that iron particles are very dense and easily settle. Coating polymer on the iron particles surface by ATRP can significantly reduce iron particles settling and improve stability of MR fluid. Two different methods are used to describe the settling behavior of MR fluids. One method is measurement of the sedimentation behavior of particles in a carrier medium through visual observation. This method is done by measuring the formation of a clear fluid layer on the surface of the MR fluid when a sample is permitted to settle for a period of time at room temperature. Another method to measure the settling behavior is characterized by measuring a sedimentation constant parameter. Polymerization kinetics of bulk butyl acrylate are investigated using differential scanning calorimetry (DSC). The overall rate of polymerization and the level of control during the polymerization are influenced by several internal variables, such as initiator catalyst, ligand, type of transferring halogen(X), and external variables such as temperature and time. The molecular weight and conversion can be controlled by the molar ratio of monomer to initiator, reaction temperature and time. The reaction is first order determined by the plot of $\ln[M]_0/[M]$ against polymerization time. The overall activation energy is found to be 126kJ/mol by Kissinger's Method. Glass transition temperature is obtained using step-scan DSC method.